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Four species of polyporoid fungi newly recorded from Taiwan

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Abstract —Four wood-rotting polypores are reported from Taiwan for the first time: *Ceriporiopsis pseudogilvescens, Megasporia major, Phlebiopsis castanea,* and *Trametes maxima.* ITS (internal transcribed spacer) sequences were obtained from each specimen to confirm the determinations.

Key words—aphyllophoroid fungi, fungal biodiversity, DNA barcoding, fungal cultures, ITS rDNA

Introduction

Polypores are a large group of *Basidiomycota* with poroid hymenophores on the underside of fruiting bodies, which may be pileate, resupinate, or effused-reflexed, and with textures that are typically corky, leathery, tough, or even woody hard (Härkönen & al. 2015). Formerly, polypores were treated mostly in *Polyporaceae* Corda s.l. (under *Polyporales*) and *Hymenochaetaceae* Imazeki & Toki s.l. (under *Hymenochaetales*), with some species in *Corticiaceae* Herter s.l. (Gilbertson & Ryvarden 1986, 1987; Ryvarden & Melo 2014). However, modern DNA-based phylogenetic studies distribute polyporoid genera across at least 12 orders of *Agaricomycetes* Doweld, e.g., *Polyporales* Gäum., *Hymenochaetales* Oberw., *Russulales* Kreisel ex P.M. Kirk & al., *Agaricales* Underw. (Hibbett & al. 2007, Zhao & al. 2015).

Most polypores are wood-rotters that decompose the cellulose, hemicellulose, or lignin of woody biomass in forests; these fungi are either saprobes on trees, stumps, and fallen branches or parasites on living tree trunks or roots and therefore play a crucial role in nutrient recycling for the earth (Härkönen & al. 2015, Ţura & al. 2016). However, some wood-rotting polypores [e.g., *Heterobasidion annosum* (Fr.) Bref. and *Phellinus noxius* (Corner) G. Cunn.] can cause serious plant diseases or decay valuable timber products, resulting in significant economic losses (Dai & al. 2007, Ţura & al. 2016); others [e.g., *Ganoderma lingzhi* Sheng H. Wu & al. and *Taiwanofungus camphoratus* (M. Zang & C.H. Su) Sheng H. Wu & al.] are medicinally important to humans (Cao & al. 2012, Wu & al. 2004).

Taiwan, which lies in the tropical and subtropical zones, is also home to some temperate climates in high montane regions. Numerous mountains and abundant rainfall produce a great variety of forest habitats, hence contributing to high fungal species richness. In Taiwan, polypores have been regionally surveyed for about a century, beginning in the early 1900s. The Japanese mycologist K. Sawada reported 30 wood-rotting polypores in his "Descriptive Catalogue of Taiwan (Formosan) Fungi" (Sawada 1959). Although Taiwanese mycologists (e.g., Z.C. Chen, T.T. Chang, S.H. Wu) have since described new species and reported new polypore records (Tzean & al. 2015), knowledge of wood-rotting polypores in the region is still insufficient.

Here we report as new to the mycobiota of Taiwan four wood-rotting polypores, which we have preserved as fungal cultures and for which we have generated DNA barcoding sequences.

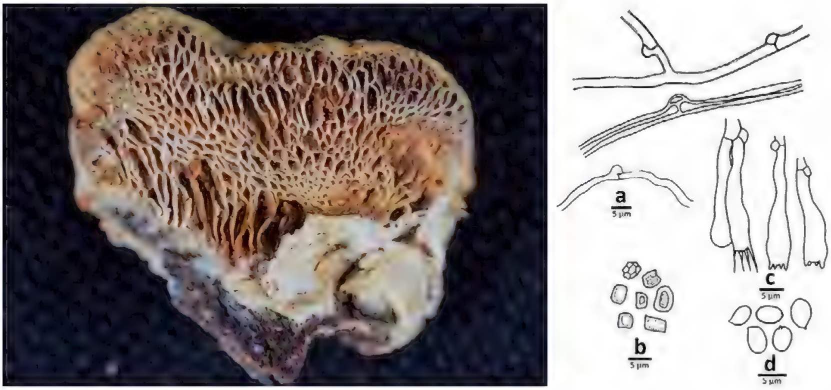
Materials & methods

Taiwanese polypore specimens collected in 2012–16 are deposited in the herbarium of National Museum of Natural Science, Taichung, Taiwan (TNM); their cultures are deposited at the Bioresource Collection and Research Center, Hsinchu, Taiwan (BCRC). Descriptions are based on dried basidiocarps. Freehand thin sections of fruiting bodies were prepared with razor blade and mounted in [i] 5% KOH with 1% phloxine stain for observation and measurement of microscopic characters and [ii] Melzer's reagent (IKI) to check amyloidity and dextrinoidity [IKI– indicates inamyloid and nondextrinoid]. Prepared slides were examined at magnifications up to ×1000 with a Leica DM2500 microscope, and line drawings were illustrated with the aid of a drawing tube. Fruiting bodies were photographed in situ or in collection using an Olympus TG-4 or Nikon Coolpix P7100 digital camera.

DNA was extracted from dried specimens or mycelia in pure culture using the Plant Genomic DNA Extraction Miniprep System (Viogene-Biotek Corp.) according to the manufacturer's protocol. We amplified the ITS rDNA region using commercial primer pairs ITS5/ITS4 or ITS1/ITS4 (White & al. 1990). The MB Mission Biotech Company purified and sequenced the PCR products, and the sequences were used to confirm species determination. Sequences newly obtained in this study were submitted to GenBank (https://www.ncbi.nlm.nih.gov/genbank/).

The scientific binomials of the presented species follow the currently accepted names on MycoBank (http://www.mycobank.org/).

Taxonomy



Figs 1,2: *Ceriporiopsis pseudogilvescens* (Wu 1209-46).
1. In collection. 2. a, generative hyphae; b, crystals; c, basidia; d, basidiospores.

Ceriporiopsis pseudogilvescens (Pilát) Niemelä & Kinnunen, Karstenia 45: 83. 2005. Figs 1,2

Basidiocarps annual, resupinate, adnate, hard and brittle when dry, up to 1.6 cm long, 1 cm wide, and 4.5 mm thick; margin pale cream to straw-colored, sterile, abrupt. Pore surface fawn to cork-colored; pores circular or angular, 2–3 per mm, dissepiments entire, ≤0.2 mm thick. Tubes concolorous with pore surface, ≤3 mm deep. Subiculum cream, homogeneous, fairly dense texture, ≤2 mm thick.

Hyphal system monomitic, hyphae nodose-septate. Subicular hyphae colorless, thin to thick-walled, 2–4 µm diam, occasionally branched. Trama with dense texture. Cystidia and cystidioles lacking. Basidia clavate, with four sterigmata, 10–28 × 5–5.5 µm. Basidiospores broadly ellipsoid, colorless, thin-walled, smooth, IKI–, 4–6 × 2.5–3.2 µm. Cubic to irregular crystals scattered in subiculum.

Specimen examined—TAIWAN. Nantou county: **Jenai Township**, Hohuanshan, 24°09′N 121°17′E, 3150 m a.s.l., on trunk of *Salix* sp., 15.IX.2012, leg. S.H. Wu, Wu 1209-46 (TNM F26731; GenBank KY688203).

Habitat—On angiosperm trunks (e.g., *Betula*, *Populus*, *Salix*) (Ryvarden & Melo 2014).

Type of rot—White rot.

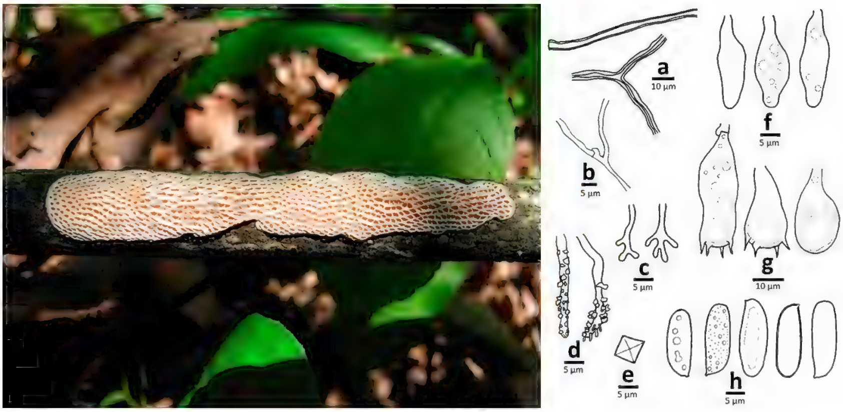
Distribution—Eurasia, East Asia, North America (Ryvarden & Melo 2014).

Remarks—*Ceriporiopsis pseudogilvescens* can be confused with *C. resinascens* (Romell) Domański, which is macroscopically similar (e.g., producing resupinate basidiocarps that become brittle when dry), occurs on the same hosts (e.g., *Betula*, *Populus*, *Salix*), and has an ITS rDNA sequence differing by only five base pairs (Tomšovský & al. 2010). *Ceriporiopsis resinascens* can be distinguished by its smaller pores (3–5 per mm) and narrower basidiospores (4.9–6.2 × 2.2–2.6 µm; Kinnunen & Niemelä 2005). The basidiospore sizes in our specimen match well with those (3.8–6 ×2.6–3.1) recorded for *C. pseudogilvescens* by Kinnunen & Niemelä (2005).

Megasporia major (G.Y. Zheng & Z.S. Bi) B.K. Cui & Hai J. Li, Mycologia 105: 375. 2013. Figs 3,4

Basidiocarps annual, resupinate, at first forming orbicular patches, then broadly effused, adnate, hard corky when dry, up to 12 cm long, 2 cm wide, and 1.5 mm thick; margin sterile, abrupt. Pore surface cream, turning cork-colored when old; pores circular or angular, 1–2 per mm, dissepiments entire, ≤0.25 mm thick. Tubes concolorous with pore surface, ≤1 mm deep; tube walls with hyphal pegs (often lacking in young specimens). Subiculum buff, homogeneous, fairly dense, ≤0.5 mm thick.

Hyphal system dimitic: generative hyphae nodose-septate, skeletal hyphae weakly dextrinoid. Subicular generative hyphae infrequent, colorless, thin-walled, 1–3 µm diam; skeletal hyphae dominant, colorless, thick-walled, 2–4 µm diam, occasionally branched. Trama densely textured. Hymenium thickened. Rare dendrohyphidia and abundant encrusted hyphal ends present in dissepiments. Cystidia lacking. Cystidioles clavate with somewhat acute apices, thin-walled, with several oil droplets, 20–24 × 7–8.5 µm. Basidia clavate to subclavate, with four sterigmata, with one to several oil droplets, 26–40 × 12–14 µm. Basidiospores cylindrical to subcylindrical, colorless,



Figs 3,4: *Megasporia major* (GC 1407-21). 3. On branch of *Cinnamomum osmophloeum*. 4. a, skeletal hyphae; b, generative hyphae; c, dendrohyphidia; d, encrusted hyphal tips; e, crystals; f, cystidioles; g. basidia; h, basidiospores.

thin-walled to slightly thick-walled, smooth, often with oily contents, IKI–, 16–24 × 5.5–7.5 µm. Pyramidal to irregular crystals scattered throughout the section.

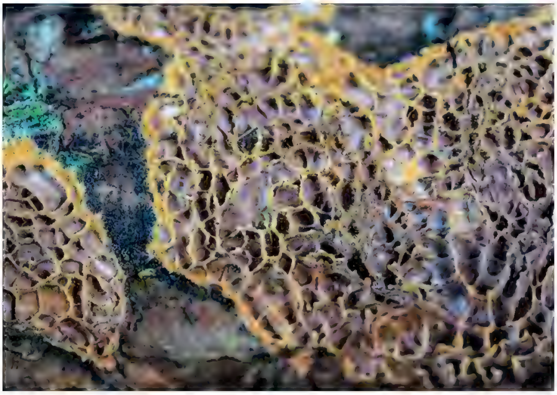
Specimens examined—TAIWAN. Nantou county: **Yuchih Township**, Lienhuachih, 23°56′N 120°53′E, 700 m a.s.l., on branch of *Cinnamomum osmophloeum* Kaneh. (*Lauraceae*), in open *C. osmophloeum* plantation, 18.VII.2014, leg. C.C. Chen, GC 1407-19 (TNM F28458, culture BCRC MU30391, GenBank KY688204); GC 1407-21 (TNM F28460, culture BCRC MU30392, GenBank KY688205); 13.IV.2015, leg. C.C. Chen, GC 1504-35 (TNM F28992); GC 1504-37 (TNM F28993); 24.III.2016, leg. C.C. Chen, GC 1603-30 (TNM F30372).

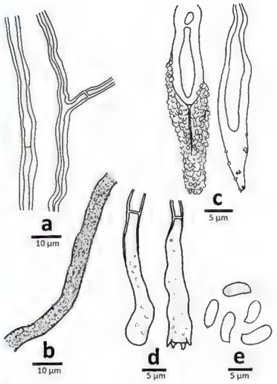
Habitat—On hanging or fallen angiosperm (e.g., *Cinnamomum*) branches and preferring an open environment (Yuan & al. 2017).

Type of rot—White rot.

Distribution—Known from tropical to subtropical areas of southern China (Guangdong, Hainan) (Dai & al. 2011, Dai & Li 2002) and Taiwan (this study).

Remarks—Within the genus, *Megasporia major* is recognized by its cream-colored pore surface and large pores and basidiospores. Although the basidiospores of the Taiwanese specimens are slightly larger than those described from mainland China (15.2–20 × 5.5–7.1 µm; Dai & Li 2002), our almost identical ITS rDNA sequences confirm the determination.





Figs 5,6: *Phlebiopsis castanea* (GC 1612-6). 5. In collection.
6. a, generative hyphae; b, hyphae covered with yellow resinous material;
c, cystidia; d, basida; e, basidiospores.

Phlebiopsis castanea (Lloyd) Miettinen & Spirin, MycoKeys 17: 25. 2016. Figs 5,6

Basidiocarps annual, resupinate, effused, adnate, corky when dry, up to 14 cm long, 3 cm wide, and 1.5 mm thick; margin sterile, cottony. Pore surface cinnamon; pores irregular or irpicoid, 1–2 per mm, dissepiments pruinose, thin. Tubes paler than pore surface, ≤0.5 mm deep. Subiculum cinnamon, fairly dense texture, ≤0.5 mm thick, composed of basal layer, ≤150 µm thick.

Hyphal system monomitic, generative hyphae simple-septate. Subicular hyphae colorless, agglutinated, thick-walled, 3–8 µm diam, occasionally branched, flexuous, covered with yellow resinous materials that dissolve in KOH. Trama with dense texture. Hymenium thickened. Cystidia projecting, conical to subulate, with acute or obtuse apices, thick-walled, apically heavily encrusted for over half of their lengths, encrustation dissolving in KOH over time, 50–60 × 10–11 µm (encrustation included). Basidia clavate, with four sterigmata, with oily contents, 28–30 × 5–6 µm. Basidiospores broadly allantoid, colorless, thin-walled, smooth, sometimes with oily contents, IKI–, 5–7 × 2–3 µm.

Specimen examined—**TAIWAN**. **Nantou county: Jenai Township**, Taiwan Forestry Research Institute, Piluchi Experimental Watershed Working Station, 24°13′36″N 121°18′32″E, 2160 m a.s.l., on branch of *Pinus* sp., in road-side, mixed coniferous forest, 3.XII.2016, leg. C.C. Chen, GC 1612-6 (TNM F30913; GenBank KY688208); **Xinyi Township**, Tatachia-Paiyun Villa, 23°29′N 120°55′E, 2700 m a.s.l., on branch of *Pinus taiwanensis* Hayata. (*Pinaceae*), 12.XI.1996, leg. S.H. Wu & S.Z. Chen, Wu 9606-19 (TNM F5053). **Taichung city: Heping District**, Pilu, 24°14′N 121°17′E, 2100 m a.s.l., on branch of *P. taiwanensis*, 14.IX.1993, leg. S.H. Wu, Wu 9304-82 (TNM F14863); Siaosyueshan, Tienchih, 24°17′N 121°01′E, 2580 m a.s.l., on branch of *Pinus* sp., 8.XI.2011, leg. S.H. Wu, Wu 1106-15 (TNM F25533).

Habitat—On gymnosperm branch (especially on *Pinus*) (Lim & al. 2005).

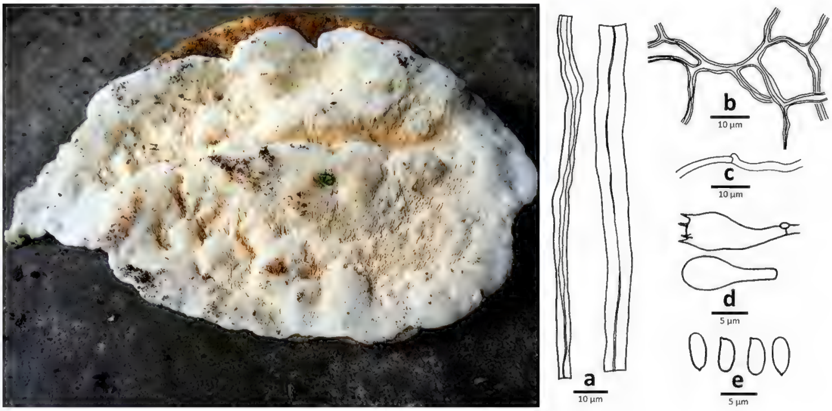
Type of rot—White rot.

Distribution—Known from temperate areas of Asia—China, Japan, Far East Russia, Northern Thailand, Korea—(Dai & Niemelä 1995, Núñez & Ryvarden 2001, Lim & al. 2005) and Taiwan (this study).

Remarks—*Phlebiopsis castanea* is placed in the genus *Phlebiopsis* Jülich based on its poroid cinnamon-colored hymenophore, broadly allantoid basidiospores, and encrusted cystidia. Our specimen produced slightly narrower cystidia while the basidiospore size fits well with previous descriptions (Núñez & Ryvarden 2001, Lim & al. 2005, as *Castanoporus castaneus* (Lloyd) Ryvarden).

Trametes maxima (Mont.) A. David & Rajchenb., Mycotaxon 22: 315. 1985. Figs 7,8

Basidiocarps annual to biannual, sessile, pileate, solitary or imbricate, hard corky when dry. Pilei semicircular to dimidiate, projecting ≤2 cm, ≤7.5 cm wide and ≤6 mm thick at base, margin obtuse. Pileal surface cream-buff to pale cinnamon, becoming greenish due to algal growth, concentrically



Figs 7,8: *Trametes maxima* (GC 1505-33). 7. In situ.
8. a, skeletal hyphae; b, binding hyphae; c, generative hyphae; d, basidia; e, basidiospores.

sulcate, glabrous to tomentose. Pore surface cream-buff; pores angular, 2–4 per mm, dissepiments entire or dentate to lacerate, thin. Tubes concolorous with pore surface, ≤5 mm deep; tube walls bear with abundant hyphal pegs. Context homogeneous, fairly dense texture, ≤1.5 mm thick, separated from pileal surface by a distinct thin black line.

Hyphal system trimitic, generative hyphae nodose-septate. Contextual generative hyphae colorless, thin-walled, 2–2.5 µm diam; skeletal hyphae colorless, thick-walled, 3–10 µm diam, unbranched; binding hyphae colorless, thick-walled, 0.5–2.5 µm diam, intricately branched. Cystidia lacking. Basidia clavate, with four sterigmata, 15 × 5 µm. Basidiospores ellipsoid to cylindrical, colorless, thin-walled, smooth, IKI–, 4.5–5 × 2–2.5 µm.

SPECIMEN EXAMINED—**TAIWAN. TAICHUNG CITY: Tungshih District**, Hsuehshankeng, 24°19′N 120°57′E, 968 m a.s.l., on angiosperm trunk, 30.V.2015, leg. C.C. Chen GC 1505-33 (TNM F29010; culture BCRC MU30393; GenBank KY688213).

HABITAT—On angiosperm trunk.

TYPE OF ROT—White rot.

DISTRIBUTION—Known from tropical to subtropical areas of East Asia (Dai 2012, Li & He 2011) and the Americas (United States, Venezuela, Colombia, Brazil) (Gilbertson & Ryvarden 1987, Gomes-Silva & al. 2010).

REMARKS—This species is characterized by its concentrically sulcate, glabrous to tomentose pileal surface, the black line in the context towards the pileal surface, its uneven pore surface, and presence of abundant hyphal pegs. Cystidioles were not found in our specimen, but the basidiospore size agrees well with previous descriptions (Gilbertson & Ryvarden 1987, Li & He 2011).

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